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May 1983

Agricultural Research

Studying Earth's Thin Crust

Our supply of food and fiber depends upon the ability of our Earth's very thin outer crust, that we call soil, to grow plants.

Soil scientists have played a key role for decades in developing ways to maintain the fertility of our soils. Research has helped farmers assess a crop's needs for soil nutrients; assess the ability of a soil to supply those needs; and to offset deficiencies through the use of commercial fertilizers.

Thanks to the dissemination of research results, farmers have a better understanding of the effect of the soil's physical conditions and microbial populations on plant growth. They are learning to determine plants' requirements for water, and to adopt irrigation and drainage practices to meet those needs.

However, while demands for food and fiber are growing, evidence is mounting that soil productivity is deteriorating faster than research can overcome problems. And projections of cropland needs suggest that by the year 2000, all of the Nation's cropland resource pool could be in production. Consequently, research on soil fertility and fertilizer-use efficiency, enhanced crop production, land and water conservation, and conservation tillage are now of special importance to U.S. agriculture.

Several research areas within the soil, water, and air sciences show particular promise as approaches to overcoming barriers to retaining and improving the soil's fertility. For example, our research increasingly reveals that microbial activity can significantly influence nutrient cycling. In fact, microorganisms play an important role in soil and water conservation, soil structure, nutrient availability, and plant health.

An increasing understanding of soil-plant-nutrient relationships is leading to basic insights on new solutions to soil fertility research problems. For example, alteration in plant membrane lipids in response to external stimuli affects the nature and functions of plant membranes. There is a correlation between iron inefficiency and aluminum (Al) tolerance in barley. Deep, active root systems prevent plant nutrient leaching. Evidence has been found for a new function of zinc in higher plants. A new method has been developed for determining organic phosphorus. Naturally occurring, complex-forming agents in organic wastes influence solubility and transport of metal ions in plants.

We must also improve the practices for restoring the fertility of eroded, mined, and marginal lands, as well as for maintaining the fertility of prime agricultural lands. Research at many ARS facilities is aimed at overcoming the adverse effects that erosion, drought, water runoff, deleterious tillage practices, acid precipitation, and many other factors are having on soil fertility.

As new conservation tillage and other practices are adopted, still more specific knowledge will be needed. For effectively managing minimum- and no-till systems, we must understand the effects large amounts of decomposing crop residues have on plant growth. We need a better understanding of how minerals, including toxic elements, move from soils into plants. We also need to study how pesticides affect the biological properties of soils and their ability to cycle and release plant nutrients.

In short, total farming systems must be studied to learn the effects and interactions of all the various components on soil fertility and plant growth.

One example of ARS's commitment to this research effort is the recent establishment of the Center for Root-Soil Research in Ithaca, N.Y. Operated by ARS in collaboration with Cornell University's School of Agriculture, the Center will be a national hub of many research programs studying the complex, variable world that exists at the root/soil interface. Attention to soil management, its relationship to root growth and crop productivity, and the recycling of nutrients from manures and sewage will be important Center priorities. It will be a truly national program, with collaborators in Beckley, W. Va., Beltsville, Md., Wyndmoor, Pa., Auburn, Ala., Lincoln, Nebr., Temple, Tex., Riverside, Calif., Kimberly, Idaho, and many other locations.

The knowledge gained from basic research at this and other ARS facilities will continue to be an important wellspring of future technology for maintaining and improving soil productivity. This research commitment underlies our mission to ensure that the Nation's natural resource base is protected for generations of Americans yet to come.

Terry B. Kinney, Jr.
Administrator, ARS

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Cover: A Minnesota farmer plants a new crop in the previous crop's residues, thereby reducing soil erosion and increasing soil fertility. However, research is needed to counteract specific problems associated with conservation tillage. Scientists around the country are studying fertilizer placement, cropping patterns, winter legumes, and many other factors that affect soil fertility under both conservation and conventional tillage practices. Article begins on p. 8. (MN-1896)

Correction: Lawrence C. Newell, ARS plant breeder, retired, developed and released Flintlock western wheatgrass instead of Kenneth P. Vogel as incorrectly stated in the March 1983 issue of *Agricultural Research*. We regret this mistake.

Poisonous Plant Seeds Yield A Cancer Inhibitor

Research chemist Richard G. Powell screens accessions to the Northern Regional Research Center seed collection for compounds useful in medicine. (1281X1557-3)

Seeds of a poisonous plant with many Latin and common names contain a potent cancer inhibitor that resembles some antibiotics produced by soil bacteria.

The "exceptionally potent" sesbanimide, isolated from *Sesbania* seed extracts, "bears in obvious structural relationship to antibiotics such as cycloheximide," says Richard G. Powell, one of an ARS-Cornell-Purdue team. Cycloheximide is produced with another antibiotic, streptomycin, by bacteria ordinarily found in soil.

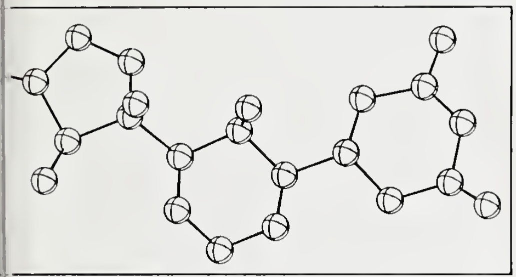
The structural similarity raises the question whether a microorganism or a higher plant actually produces sesbanimide. "Further study may be necessary to clarify its origin," Powell says. "We have no evidence now to support the view that it is of microbial origin." The team found it in *Sesbania* species that grow on the coastal plain in Southern and Southeastern States.

Although sesbanimide resembles some antibiotics, its "tricyclic structure is unusual," Powell says. "The structure of many compounds includes three rings of atoms, but it is highly unusual to have three rings linked by single bonds." One ring in sesbanimide is identical to a ring in cycloheximide, streptimidone, and streptovitacin, all antibiotics.

Sesbanimide was isolated from seed extracts, its structure determined, and its antitumor activity demonstrated by Powell, Cecil R. Smith, Jr., and David Weisleder, Northern Regional Research Center, Peoria, Ill.; Gayle Matsumoto and Jon Clardy, Cornell University; and John Kozlowski, Purdue University. Smith leads a Northern Center group looking for useful compounds in plants. They have found more than 10 pest control agents or cancer inhibitors in 1,200 to 1,300 analyses of seeds and other plant parts.

In National Cancer Institute assays, sesbanimide demonstrated antitumor activity "at exceptionally low dose levels" in mice with leukemia, Powell says. Mice that received .01 mg of sesbanimide per kilogram of body weight survived leukemia 1.71 times as long as mice that received none. In other words, each treated mouse weighed a hundred million times as much as each dose it received. Sesbanimide also demonstrated toxicity to cells of human carcinomas growing in cell cultures in the Institute's assays.

Powell isolated about 0.0005 lb of sesbanimide, as a white solid, starting with about 1,000 lb of *Sesbania drummondii* seed (0.00005 percent yield from 454 kg of seed).



Finding antitumor activity in extracts from seed of three *Sesbania* species more than 6 years ago, Powell and others at the Northern Regional Research Center began work to isolate the active compound. By 1981, they isolated and described the structure of two inactive compounds, drummondol and sesbanine.

The present team separated sesbanimide from sesbanine by what Powell calls a "complex scheme of successive chromatographic methods" and determined the structure by X-ray crystallography and nuclear magnetic resonance spectrometry.

The *Sesbanias*, also called *Daubentonia* and *Glottidium* or, commonly, rattlebrush, coffeebean, and rattlebox, are very poisonous to livestock, especially sheep. The USDA Agriculture Handbook, "Selected Weeds of the United States," says *Sesbania* species are perennial, herbaceous shrubs or small trees. They are legumes. Nitrogen-fixing bacteria live on their roots.

These poisonous plants grow in sandy soils of waste places, along roads, and in fence rows on the coasts from North Carolina, through Florida and Texas to Mexico.

Among cancer inhibitors Smith's team reported earlier are harringtonines from a plumyew tree that grows in China, trewia compounds from the false white teak, an Indian tree, and cephalomannine, from a coniferous tree, *Taxus*. Homoharringtonine is in clinical trials under the direction of the National Cancer Institute. Some of the harringtonines are used now against leukemia in the People's Republic of China.

Richard G. Powell is located at the Northern Regional Research Center, 1815 N. University, Peoria, Ill. 61604.—(By Dean Mayberry, Peoria, Ill.) ■

Top, left: A computer-generated image of the molecular structure of sesbanimide reveals three distinctive rings linked by single bonds. The linkage is unprecedented. (PN-7035)

Above: Coffeeweed *(Sesbania punicea)* is a poisonous legume which may contain the cancer inhibitor sesbanimide. *S. punicea* is closely related to *Sesbania drummondii*, from which scientists have isolated sesbanimide. (PN-7031)

Above: Generations of selection to improve sow productivity at Beltsville, Md., have paid off as demonstrated by this "thrifty" litter of Yorkshire pigs. (0383X302-9)

Left: Animal geneticist Ben Bereskin with a purebred Yorkshire boar whose sire and dam are from genetic lines of above-average sow productivity. (0383X301-30A)

Accurately predicting sow productivity can mean the difference between profit and loss for hog farmers. Now there is a new method that promises to be up to 62 percent more accurate than the present system for determining a young herd replacement's potential.

"Practically all programs currently being promoted to improve sow productivity by selection rely solely on productivity records of the dams (mothers) of young boar (male) and gilt (unbred female) candidates for the breeding herd," says Ben Bereskin, ARS research animal geneticist. "The sire's side of the pedigree, whose contribution to the genetic merit of the offspring essentially equals that of the dam, has largely been ignored," he states.

According to Bereskin, a better basis for evaluating and selecting young herd replacements is to estimate their breeding value using records of the candidate's most immediate ancestors—both the sire and the dam. The estimated breeding value (EBV), which thus includes a proof of the sire, can then be used as a supplement to the standard index of sow productivity, which traditionally has been used alone for selecting herd replacements. This index rates sow productivity per litter and includes such factors as number of live pigs farrowed (born), number of pigs alive, and their total litter weight at some standard age, such as 21 days.

"A sire's proof should include productivity records for a minimum of three and preferably six or more daughters in order to be used in the evaluation," says Bereskin. "Until such a proof is available, records for the sire's own parents can be substituted in the evaluation."

Bereskin conducted theoretical calculations to compare the advantages of using different combinations of records from the sire's side of the pedigree in addition to records for the dam in evaluating young boars and gilts for sow productivity.

For example, he found that when a proof based on six daughters of the sire is used along with records for the dam, the accuracy of the EBV for the candidate is increased by 62 percent over that when only the dam's sow productivity index is considered. When records for the sire's dam or both of the sire's parents are substituted for the sire's proof, up to a 28-percent increase in EBV accuracy can be achieved.

"A major advantage in using EBV is that it allows an easy system of application in practice," Bereskin says. "This is because half of these genes represented by EBV are inherited from each parent and a sample half of the full complement of genes are then passed on to each offspring," he continues.

According to Bereskin, the producer only needs two basic equations to compute the EBV for all animals in the herd. One equation is for sows that have farrowed and the other is for boars that have daughters which have farrowed in the herd. Each productivity record is expressed as a percentage deviation, either plus or minus, from the contemporary herd average for the sow with the record. In this way, changes over time in the environment or management of the herd can be compensated for, providing a more equitable evaluation of each animal's EBV.

"One of the best ways a seed-stock producer can raise the genetic level of sow productivity in the herd—a way that is probably least used today—is to increase the accuracy in evaluating the EBV's of young breeding herd candidates, both boars and gilts," Bereskin notes. "Use of the proposed procedures will provide a sound basis for improving that evaluation and selection process," he concludes.

Detailed guidelines, including examples, for applying the proposed methods have been developed. Copies are available at the address listed below.

Ben Bereskin is located at the Nonruminant Animal Nutrition Laboratory, Bldg. 200, Beltsville Agricultural Research Center-East, Beltsville, Md. 20705.—(By Ben Bereskin, with assistance from Vince Mazzola, Beltsville, Md.) ■

Cotton Insect Biocontrol Takes A Big Step Forward

A major obstacle in the laboratory rearing of a parasite wasp of the cotton bollworm and the tobacco budworm has been overcome, and research now moves closer to the economical biological control of at least two very destructive insect pests.

With the discovery of a powerful artificial oviposition (egg-laying) stimulant, ARS entomologist W. C. Nettles, Jr., and his coworker R. K. Morrison, along with researchers from Texas A&M University and China, have cleared the way for an entirely new phase of research on *Trichogramma*, a promising biological control agent of the cotton bollworm and tobacco budworm (*Heliothis*).

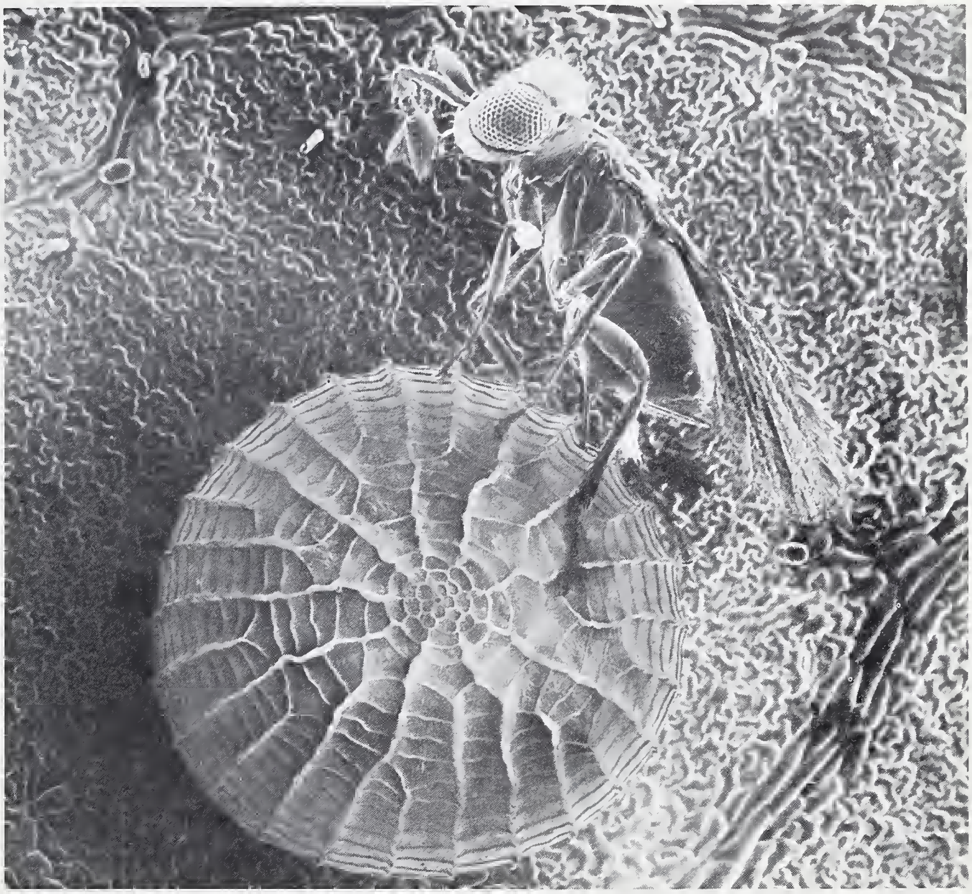
Heliothis zea and *Heliothis virescens*, or the bollworm-tobacco budworm complex as the pests are commonly called, inflict enormous losses on cotton each year. Worldwide, members of the genus *Heliothis* cause an annual economic loss of over $1 billion in the crops they attack.

Trichogramma is an effective natural control agent of the bollworm-tobacco budworm complex (as well as many other insect pests) but its use in field release programs has been restricted to some extent by the difficulty of producing host eggs in the laboratory.

Essentially, two insects must be reared in the current production system—the parasite and a surrogate live host. Rearing two insects to get a few parasites can be complex and costly. However, it is done, especially in China where an abundance of hand labor and a cropping system of small plots make the release of small numbers of *Trichogramma* effective.

Western cropping systems, on the other hand, would require much large numbers of the parasite, and Nettles' discovery is a major step in that direction. His oviposition stimulant is as effective as a host egg in stimulating the wasps to deposit eggs. This development could eventually lead to the elimination of live hosts from the production system as well as to a huge increase in the number of *Trichogramma* that could be produced.

The new stimulant, which is an inexpensive solution of potassium chloride and magnesium sulfate, is incorporated into an artificial oviposition growing medium. The parasite eggs deposited in this medium can then be harvested and the parasites reared on an artificial diet used in augmentative releases. (The term "augmentative" is used to describe the releases because the parasite wasp exists in nature, but in small numbers.)



A *Trichogramma* wasp, parasitic to the cotton bollworm and tobacco budworm *(Heliothis)* prepares to lay eggs on a *Heliothis* egg. The scanning electron micrograph is made by placing wasps in a chamber with *Heliothis* eggs on cotton leaves until one settles down on an egg for egg-laying. Then the wasp, eggs, and leaves are transferred to the specimen chamber of the electron microscope, where the wasp is stunned by the vacuum and photographed. (PN-7049) (Photo by Gerald R. Carner, Clemson Univ.)

Nettles and his associates are now working on a strictly artificial diet that would contain everything the wasp needs to grow and mature.

"Put it this way," says the scientist, "there were two major obstacles in the way of large-scale *Trichogramma* rearing—the lack of an ovipositional stimulant to enable us to collect large numbers of eggs, and a good artificial diet. We have overcome the one obstacle and, because we now have an inexpensive method of collecting many thousands of eggs, we are making good progress toward overcoming the other."

The bollworm, *Heliothis zea*, feeding on a cotton boll. Each year, members of the genus *Heliothis* inflict enormous losses on crops worldwide. (0982X1102-25)

W. C. Nettles, Jr., is located at the Cotton Insects Research Laboratory, P.O. Drawer DG, College Station. Tex. 77841—(By Bennett Carriere, New Orleans, La.) ■

Soil erosion is one of the most severe challenges to soil fertility in the United States. (0582X526-13A)

Soil fertility is an increasingly important focus of agricultural research. World population growth, the leveling off of crop yields, the conversion of prime farmland to nonagricultural uses, the entry of marginal lands into production, the rising costs of fertilizers, and other problems are placing great stress upon the productivity of the soil.

Because of modern agricultural practices, many soils of the United States now contain more abundant reserves of some plant nutrients than they did when first cultivated. The cattle of New Hampshire colonists suffered from a wasting disease which we now know was due to the soil's natural lack of cobalt. In the Pacific Northwest, zinc deficiency along the Columbia River was once so severe that irrigated corn and bean crops failed on many farms. Agricultural scientists have diagnosed and helped farmers to correct many such problems.

It is erosion, however, that presents one of the most severe challenges to soil fertility. On nearly a third of the Nation's 413 million acres of cropland, erosion annually exceeds 5 tons of soil per acre—a rate of loss up to 10 times greater than the natural rate of replacement. One-third of the Nation's corn acreage, 44 percent of soybean, 34 percent of cotton, and 39 percent of all sorghum acreage suffers from such loss. Sixty percent of the country's rangeland is in poor to fair condition and produces less than half its potential.

Losses in productivity, however, have been more than offset in recent decades by record harvests largely made possible by improved crop varieties; increased use of irrigation, fertilizers, and pesticides; and good weather. Degradation of productivity, however, is an accelerating and self-reinforcing process: this year's losses contribute to increasing losses in the years to follow. As costs rise and soil productivity falls, high rates of production become difficult to sustain.

Crops themselves take a heavy toll upon the soil. Thirty pounds of phosphorus are removed with every 50 bushels of wheat. Hawaii exports 2,200 tons of potassium each year in its pineapple crop alone. Losses of nitrogen and sulfur follow similar patterns.

To reverse the general decline in soil productivity, ARS scientists are engaged in a national cooperative effort to—

- Increase basic knowledge of soil productivity;
- Develop innovative technologies for reducing erosion and improving the profitability of many farm operations;
- Predict the fertilizer needs of crops for maximum long-term production.
- Develop improved soil and crop management practices for most efficient use of fertilizer, energy, and water resources.

• Determine how best to manage fertilizers and naturally occurring nutrients for high yields and improved nutritional quality of crops.

The following paragraphs are but a few examples of ARS and ARS-cooperative research in the area of soil fertility.

LINCOLN, NEBR.—In an effort to better understand the effects of tillage on soil fertility, researchers with the Soil and Water Conservation Research Unit here have found that the combination of greater biomass and less aeration in nontilled soils leads to lower levels of plant-available nitrogen in the top 3 inches of soil. This can be overcome, however, by placing fertilizers below that top layer of soil (see "Tailoring Fertilizer Placement," p. 12).

Other Lincoln research shows that soybean and corn yields increase as the amount of crop residue left on the field increases. Higher yields are largely due to an increase in the number of beans or kernels per plant.

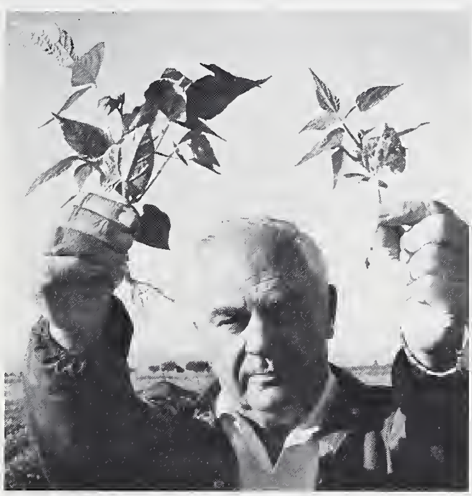
FORT COLLINS, COLO.—Scientists at the Soil-Plant-Water Research Unit developed a method for measuring the rate at which organic phosphorus changes into a form that plants can take up. The technique, which uses radioactive markers, can be used to enhance soil phosphorus research.

KIMBERLY, IDAHO—Cropping patterns can have a marked effect on the amount of zinc (and possibly other nutrients) in the soil. Scientists at the Soil Management and Water Quality Research Laboratory have found that corn recycles enough zinc through its roots in 2 years to keep a subsequent crop of zinc-sensitive plants from becoming deficient. By contrast, a year of beans preceded by 2 years of fallow did not.

BYRON, GA.—Scientists at the Southeastern Fruit and Nut Tree Research Laboratory found that winter legumes can supply a major portion of the nitrogen requirements for mature pecan orchards. A winter cover of arrowleaf clover, which was allowed to decompose on the orchard floor during the summer, supplied pecan trees with the equivalent of 100 lb of nitrogen fertilizer per acre (112 kg/ha).

SIDNEY, MONT.—Sweetclover could potentially replace nitrogen fertilizer in small grain crops, according to researchers at the Northern Plains Soil and Water Research Center. After being plowed into the soil, the legume produced yields of winter wheat more than twice that of unfertilized fields. Yields were comparable to those of fields that had received 40 lb of nitrogen fertilizer per acre (45 kg/ha).

Above: Soil scientist Glen Leggett walks among experimental plots at Kimberly, Idaho, where the effects of various cropping practices on the level of zinc in the soil are being measured. Signs were placed in the fields as part of an open house and demonstration of conservation techniques. (0782X770-13)



Leggett holds two bean plants that show the effects of zinc on growth. The plant on the left received a zinc supplement; the plant on the right received none. (0782X771-35)

Other Sidney research showed that a single heavy application of phosphorus can maintain bumper winter wheat yields for many years in dryland farming. Each acre that received 160 lb of phosphorus (180 kg/ha) in 1967 was outproducing the untreated fields by more than 7½ bu per acre (517 kg/ha) in 1981. Chemical tests verified that phosphorus levels were still adequate for optimum yields after 14 years.

RIO PEDRAS, P.R.—Scientists at the Soil and Water Conservation Research Unit here found they can put rum distillery slops to good use as fertilizer while eliminating the high cost of disposing of this waste product. Adding 1,053 gal per acre (10,000 l/ha) of the residue to the irrigation water each week provided all the nitrogen and potassium required to produce high yields—more than 6,500 lb of rice per acre (7,400 kg/ha).

BELTSVILLE, MD.—Field studies by Biological Waste Management and Organic Resources Laboratory researchers have shown that severely disturbed lands, such as sand and gravel spoils, can be restored to high fertility in 3 to 5 years with the proper use of organic wastes, especially composted sewage sludge. However, the sludge should be free of heavy metals. A study on the long-term use of sludge revealed that nearly 100 percent of cadmium residue was in a plant-available form.

Sewage sludge compost (if free of toxic metals) together with animal manure can provide a substantial amount of the nutrients needed for growing vegetables on marginal soils. The combination of organic wastes pro-

Researchers at Rio Piedras, P.R., are working with experimental plots of rice to test the possibility of using rum distillery slops as fertilizer. (0680X633-24)

duced higher yields and better quality cabbage, tomatoes, and cauliflower than commercial nitrogen fertilizer alone, and is particularly suited to small commercial growers and pick-your-own operations.

PROSSER, WASH.—Without reducing their harvests, Pacific Northwest potato growers could save 35 to 55 percent of their costs for nitrogen fertilizer by applying less. Researchers at the Soil and Water Management Research Laboratory here found that 270 lb of nitrogen fertilizer per acre (300 kg/ha) was sufficient for optimal yields.

BECKLEY, W. VA.—Better legumes for the soils of Appalachia are on the

Plots of lettuce treated with sewage sludge compost at Beltsville, Md., showed higher yields than those treated with commercial nitrogen fertilizer alone. The higher yields resulted from supression of a root disease by the compost. (1180A1396-22)

Soil Bacteria: Another Source of Nitrogen?

A number of ARS scientists are looking beyond legumes and fertilizers as sources of nitrogen for cereal crops. They are trying to capitalize on the free-living bacteria and blue-green algae that fix atmospheric nitrogen into a form usable by plants.

Unlike th erhizobia which are housed in nodules on legume roots, these microorganisms live in the soil close to the roots of cereals and other grasses, and therefore must bridge the gap between themselves and plant roots. A few species of bacteria that scientists presume to be "associative" have been found in soils around the world.

Stephen L. Albrecht and Murray H. Gaskins, plant physiologist and research leader with the Plant Science Research Unit in Gainesville, Fla., believe that if soil bacteria could be made to provide 25 percent of the nitrogen fertilizer recommended for corn in the sandy soils of the Southeast, it could save 500 cubic feet of natural gas consumed to produce the ammonia fertilizer recommended for each acre (35.4 cu m/ha). The long-range goal, say the researchers, is to "make cereal crops as nearly self-sufficient as possible for their nitrogen needs." However, the goal is a long way down the road.

Albrecht says that scientists will have to accomplish three things: Select and breed cereals that release more carbon compounds through their roots to provide more energy for the nitrogen-fixing microorganisms; find methods of altering the soil microflora cheaply so

horizon. Scientists at the Appalachian Soil and Water Conservation Research Laboratory found a significant amount of genetic variability within the species of six different clovers and birdsfoot trefoil. Certain types proved to be better suited to adverse soil and climate conditions than others, thus providing such areas with a possible nitrogen-fixing crop.

ITHACA, N.Y.—Scientists with the U.S. Plant, Soil, and Nutrition Laboratory have shown that nickel may be an essential micronutrient for soybeans, cowpeas, and possibly for higher plants in general. Nickel deficiency resulted in an excessive accumulation of urea in leaflet tips. This suggests that the nickel-dependent enzyme urease may have a major role in nitrogen use by plants.

Plants growing in moderately zinc-deficient soils are usually susceptible to phosphorus toxicity, and the application of phosphorus fertilizers should be avoided. Zinc is required to maintain the integrity of cell membranes. Plants low in zinc have "leaky" membranes that—among other things—allow them to leak fluids and lose turgidity.

Study of "grass tetany," a disease of grazing animals caused by magnesium deficiency, has led ARS and New York State scientists to successfully supplement animal diets with magnesium added to the water or soil in critical areas and seasons.

—(By Andy Walker and Judy McBride, Beltsville, Md.) ■

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that the nitrogen-fixing microorganisms do not have to contend with too much competition from other microorganisms; and insure that the fixed nitrogen is taken up by the plant, not by other soil organisms.

As a first step, the two scientists have established that nitrogen compounds from species of *Azotobacter*, *Klebsiella* and *Azospirillum* genera of associative bacteria do, in fact, move inorganic nitrogen compounds into plants—although at a very low rate. They also are currently studying a number of pearl millet types selected at the University of Georgia that appear to secrete more carbon compounds through their roots. Using radiolabeled carbon, the researchers will identify and measure the compounds that move into the surrounding microorganisms.

In related research, microbiologist Paul E. Bishop of the Soybean and Nitrogen Fixation Research Laboratory in Raleigh, N.C., found a strain of the associative bacterium, *Azotobacter vinlandii*, that does not appear to require molybdenum—an element believed to be essential to the process of nitrogen fixation. The discovery could be important for those areas of the world where soils lack molybdenum, such as in the Southeastern United States and Brazil.

Charles Sloger, plant physiologist with the Nitrogen Fixation and Soybean Genetics Laboratory at Beltsville, Md., takes a more conservative view of the potential for associative nitrogen-fixing bacteria.

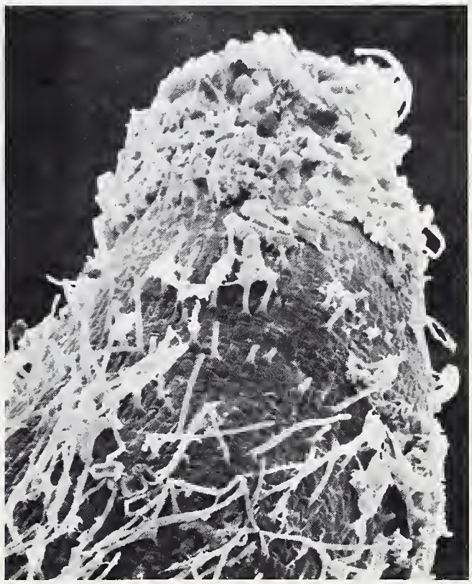
While studying wild rice and cordgrass in their natural aquatic habitats,

Plant physiologist Charles Sloger and Peter van Berkum, a cooperating biochemist from the University of Maryland, inspect rice seedlings growing in salt marsh sediment. The scientists have found that associative bacteria in the sediment stimulate nitrogen fixation on the roots of rice and marsh grasses. (0180X096-20)

Sloger and biochemist Peter van Berkum found that the nitrogen-fixing activity of associative bacteria relates inversely with the availability of nitrogen in their environment: the higher the nitrogen level, the lower the nitrogen-fixing activity. "That situation is not compatible with intensive agriculture," Sloger says.

In addition, the amount of fixed nitrogen that does move into the grasses is so small that the plants remain nitrogen-deficient. Thus, Sloger would add a fourth obstacle to Albrecht's list: Scientists will have to find a way to encourage the bacteria to fix nitrogen under agricultural conditions where soil nitrogen is relatively more plentiful than in aquatic environments.

But Sloger is still optimistic. Genetic engineering may overcome some of the obstacles. Another solution may be to use nitrogen-fixing bacteria that get inside the roots in much the same manner



A scanning electron micrograph of a root tip from a sorghum *(Sorghum bicolor)* plant with kidney bean shaped bacteria *(Azospirillum brasilense)* on its surface. Such nitrogen-fixing bacteria may live on the root surface or in the surrounding soil. The white, threadlike projections are root hairs. (PN-7048) (Photo by Howard Berg, Univ. of Florida)

as pathogens do. He and van Berkum have found several nitrogen-fixing bacteria inside the roots of cordgrass, but, for the present, their identity remains to be established. "We don't know the mechanisms by which they invade the roots," Sloger says.

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Tailoring Fertilizer Placement

Corn is planted and fertilized in a single pass through the field. Under conservation tillage conditions such as this, the fertilizer should be placed 3 inches below the biologically active surface zone to keep microorganisms from immobilizing the nitrogen. (IA 2855)

Increased fertilizer requirements that often accompany reduced tillage may be curtailed by tailoring the placement of fertilizer applications to the intricate balance between living and nonliving components of the soil.

Placing fertilizer below the biologically active surface zone in reduced tillage systems could cut nitrogen fertilizer needs by 15 to 25 lb per acre below what would be needed with surface broadcast applications, says ARS soil scientist John W. Doran, Lincoln, Nebr.

"Microorganisms eat at the table first," says Doran. "With more microorganisms in no-till soil, there are simply more things there to eat the nitrate nitrogen before the crop can get it."

Doran's study shows that farmers can easily overcome extensive immobilization of nitrogen by microorganisms by placing the fertilizers 3 to 4 inches into the soil or concentrating it in a narrow zone at the surface.

In connection with a 1975 USDA report that projects 65 percent of the Nation's row-crop land in conservation tillage by the year 2000, Doran's idea for increasing fertilizer efficiency translates into big savings nationally. If 75 percent of that land is well to moderately well drained, projected fertilizer costs with conservation tillage could be reduced $300 to $600 million annually in today's dollars.

Doran's estimates are based on a 4-year study of soils at seven sites from West Virginia to Oregon. He studied soil samples from no-till and conventionally tilled plots that had been in continuous corn or wheat-fallow rotation for at least 5 years and in some places as long as 12 years.

No-till and conventionally tilled soils differed greatly in amount and composition of water, soil gases, mineral, organic matter, and in numbers of various types of microorganisms, especially in the top 3 inches. Doran says these differences can cause crops to respond differently to fertilizer practices.

Doran's study showed that the density of the no-till soil was usually higher than that of plowed soil, and its pore space was more sufficiently filled with water. He associated these differences with differences in biological activity. In the no-till soils he found that organic matter, water content, and numbers of aerobic microorganisms (those active in the presence of oxygen) averaged 35 percent greater than in plowed soils.

In the top 3 inches of the no-till plots, aerobic bacteria and fungi were 41 and 57 percent more prevalent, respectively, than they were at the same depth in plowed plots.

It was no surprise to find a high concentration of soil microorganisms near the surface of no-till soil, because the organic matter is concentrated there rather than throughout the plow layer, says Doran. However, this causes a fertilizer efficiency problem: The greater numbers of microorganisms in the top 3 inches of soil immobilize the nitrogen from nitrates and ammonium into organic forms of nitrogen that plants cannot immediately use. Placing fertilizer below that top soil layer or in a narrow band at the surface keeps much of it out of the microorganisms' reach.

Increased nitrogen-use efficiency with fertilizer placement in no-till crops has been confirmed by recent experiment station trials in Indiana, Iowa, Minnesota, Kentucky, Georgia, and Maryland. At the Maryland locations, soil fertility scientist V. Alan Bandel found that no-till corn yields averaged 20 percent higher where nitrogen was subsurface-applied or dribbled in a narrow zone on the surface than where it was broadcast.

Even with tailored fertilizer placement, conservation tillage will still require more fertilizer than conventional tillage. However, that extra cost will not be all lost, Doran says. Some of the extra nitrogen will help build up organic matter in the soil. And that is in addition to the other advantages of reduced tillage—fuel and labor savings, water conservation, and reduced soil erosion.

Doran says further research on the interaction of water, aeration, and temperature regimes in various soil and climatic regions across the country may provide a unified basis for developing production practices that enhance farm profits and conserve soil resources.

John W. Doran is located in Rm. 116, Keim Hall, University of Nebraska, Lincoln, Nebr. 68583.—(By Ben Hardin Peoria, Ill.) ■

Probing Sclerotinia Disease in Forage Legumes

Crimson clover *(Trifolium incarnatum).* (0583X495-6A)

Perennial clovers, alfalfa, and other legumes in northern areas of the United States, Canada, and Europe are particularly susceptible to Sclerotinia crown and stem rot caused by the fungus *Sclerotinia trifoliorum* Erikss.

The incidence and severity of this widespread and potentially destructive disease vary from year to year and are related to winter temperatures and rainfall. Little is known of how damaging Sclerotinia crown and stem rot actually is on forage legumes in the Southeastern United States, or of events in the development of the disease cycle there.

In research conducted jointly by ARS and Mississippi State University, scientists are studying times and conditions under which sclerotia (compact masses of hardened filaments) of *S. trifoliorum* germinate in the soil. Upon germination, these masses form above-ground apothecia (fruiting bodies that release air-borne spores) which initiate the disease cycle in crimson clover.

The scientists are also attempting to determine whether sclerotia can be added to soil to provide consistent levels of this erratically occurring disease for field investigations directed toward its control.

Results of studies by plant pathologist Robert G. Pratt and agronomist William E. Knight show that sclerotia collected from diseased plants in the field will produce fruiting bodies and initiate disease in crimson clover after storage and burial in soil under proper conditions. Sclerotia produced in culture, however, seldom produce apothecia. The results suggest that sclerotia may be collected, stored, and added back to soil to provide disease for evaluation of plants and effects of potential cultural control practices under field conditions.

Data obtained to date indicate that for maximal production of apothecia at the Starkville, Miss., research site, sclerotia should be collected in the spring, stored air-dry at 25° C, and buried up to 1 cm deep in soil beneath growing crimson clover no later than early October. Burying sclerotia at greater depths, or delaying their addition to soil, can greatly decrease numbers of fruiting bodies subsequently formed.

Sclerotia in *S. trifoliorum* formed apothecia primarily in December in Mississippi. This is considerably later than in areas farther north. In Kentucky, North Carolina, and the Netherlands, apothecia were reported to be most numerous in October. In England, apothecia were abundant as early as August, and production ceased by November. However, despite the different times at which fruiting bodies formed, the spread of new filamentous growth (mycelium) from spores and the death of crop plants occurred at the same time (January to March) in Mississippi as in all of the areas farther north.

Winter temperatures and rainfall appear to affect mycelial spread and disease development by *S. trifoliorum* in Mississippi as in other areas. The foliage on clover began to rot in January 1980 with near-normal temperatures and above-normal rainfall; in February 1979 with below-normal temperatures and above-normal rainfall; and in March 1981 with near-normal temperatures and below-normal rainfall. These observations suggest that the disease is favored by mild temperatures and abundant rainfall during the winter growing season.

Robert G. Pratt and William E. Knight are located at the Delta States Area Crop Science Research Laboratory, P.O. Box 5367, Mississippi State, Miss. 39762.—(By Neal Duncan, New Orleans, La.) ■

ELISA Improves Curly Top Monitoring

Yet another use has been found for ELISA (enzyme-linked immunosorbent assay), an efficient virus-detection technique of long standing.

Plant pathologist David L. Mumford, Logan, Utah, has found that ELISA can be used to monitor curly top virus in field populations of beet leafhoppers.

Curly top ranks as one of the worst diseases of sugarbeets, tomatoes, dry, lima and snap beans, cucumbers, and muskmelons in the United States. To control it, large populations of its primary carrier, the beet leafhopper, are located and sprayed with insecticides.

Currently, virus-carrying leafhopper populations are identified by caging individual leafhoppers on sugarbeet seedlings and waiting 2 weeks to see what percent of the seedlings become infected. The procedure is accurate, but takes too long. The erratic pattern of curly top outbreak, caused by unpredictable fluctuations in virus-carrying leafhopper populations, demands a faster means of identifying potential trouble spots.

Mumford applied an ELISA technique, developed to detect viruses in animal blood and plant juices, to the curly top situation. He caged leafhoppers on infected sugarbeets either individually or in groups of 5, 10, and 20. He then periodically removed the insects, ground them up, and ran them through the ELISA process to determine if the virus could be identified and how much time was required to do so.

In the groups, curly top virus was detected after 8 hours' exposure on the infected plant. It required 24 hours' exposure to detect the virus in individually caged insects. Field tests conducted over a 2-year period on 21 and 38 test sites in California suggest that ELISA determinations of virus levels in leafhoppers may reflect disease levels in commercial crops.

Quickly and accurately monitoring field populations of beet leafhoppers will reduce losses to curly top by improving the timeliness and effectiveness of control measures.

David L. Mumford is located at the Crops Research Laboratory, Utah State University, Logan, Utah 84322.—(By Lynn Yarris, Oakland, Calif.) ■

Save That Topsoil

Above: Massee inspects a healthy stand of wheat on the test plot where 6 inches of topsoil was added. (0782X765-14A)

Right, top: Soil scientist Truman Massee and biological technician Harold Waggoner measure sparse wheat growth on the test plot where 12 inches of topsoil was removed. Wheat production on this plot was 70 percent below that on the undisturbed, unfertilized plot. (0782X759-34)

Right, below: That topsoil loss reduces wheat yield is graphically demonstrated by these wheat heads: the one on the left is from a plot where no soil was removed; the one on the right is from a plot where 6 inches was removed. (0782X768-19)

What has long been suspected has finally been demonstrated scientifically: loss of topsoil substantially reduces wheat yields.

Truman Massee, a soil scientist at the Snake River Conservation Research Center, Kimberly, Idaho, conducted a study to measure soil productivity losses caused by erosion and evaluate the use of fertilizers to reverse such losses.

So crucial to productivity was the loss of topsoil in his study, that Massee says, "Growers would probably be better off returning topsoil from runoff to their fields rather than adding more fertilizer."

Runoff erosion from melting snow and rainstorms is an ongoing problem for the millions of acres of steep-sloped, dry cropland throughout the Pacific Northwest and the intermountain areas of Idaho, Montana, and Utah. Sometimes this erosion is insidious and sometimes it is flagrantly apparent in the form of light-colored spots or patches spattering a field.

"When you see these light spots, that is where the topsoil has been lost and crop yields have become so sparse that the soil is visible," says Massee.

To determine just how much the loss of topsoil affects yields, Massee began his study 3 years ago at two different 2-acre test sites. One site featured 14 to 17 inches of topsoil on an eastern slope of about 3 percent. The other site had 7 to 11 inches of topsoil on a western slope of nearly 8 percent.

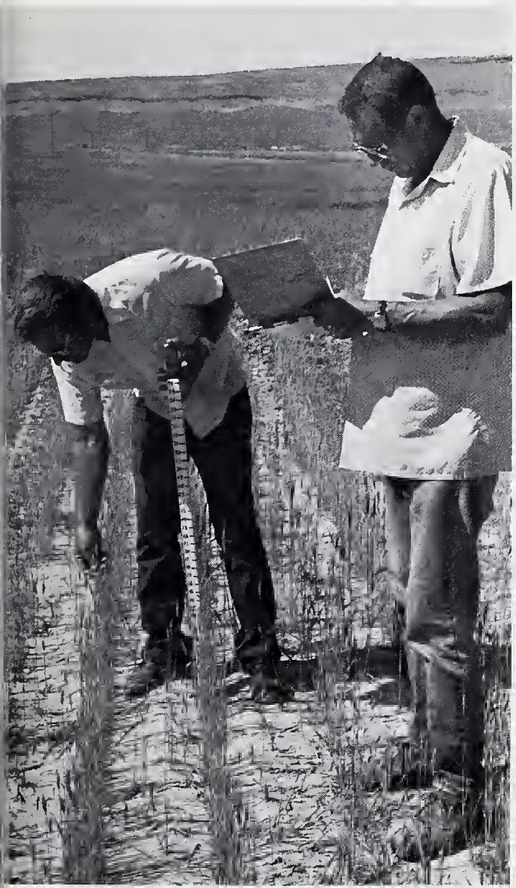
Both test sites were divided into four treatment areas and were cropped with Hard Red Winter wheat. Six inches of topsoil were removed from one treatment area and added to a second. Twelve inches of topsoil were removed from a third treatment area and the topsoil from the fourth area was left undisturbed.

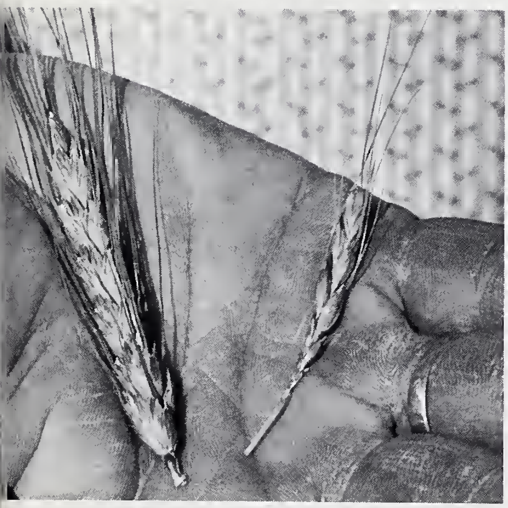
One-third of the plots in each treatment area received 60 pounds per acre of nitrogen fertilizer, one-third received 30 pounds per acre, and the remaining third received none. Half of the plants in the study were given 48 pounds per acre of phosphorus fertilizer. All the other variables, such as other trace elements or soil moisture, were kept as equal as possible. Results from both test sites were combined.

On the plots where 12 inches of topsoil were removed and no fertilizer was applied, production fell to 6.4 bu per acre—more than 70 percent—from the 21.4 bu per acre harvested from plots with undisturbed, unfertilized topsoil.

Only by adding 60 pounds per acre of nitrogen to areas losing 12 inches of topsoil could production be lifted above that of undisturbed, unfertilized topsoil—to 27.6 bu per acre.

Even the addition of 60 pounds per acre of nitrogen fertilizer, however, left the 12-inch, topsoil-loss areas a dozen bushels per acre under the productivity of the treatment areas receiving 6 additional inches of topsoil and no nitrogen fertilizer.





The addition of phosphorus had no significant impact on wheat yields, according to Massee, who plans to continue to collect data for at least 2 more years.

Truman Massee is located at the Snake River Conservation Research Center, Rt. 1, Box 186, Kimberly, Idaho 83341.—(By Lynn Yarris, Oakland, Calif.) ■

New Technique to Measure Nitrogen Losses

The loss of nitrogen fertilizer from farmland is an economic problem for farmers and, if large amounts are lost, it causes a potential water-pollution problem.

A simple, new technique that permits the measurement of most of the nitrogen (either ammonium or nitrate) that is leached from agricultural land has been tested by Ronald R. Schnabel, a soil scientist at the Northeast Watershed Research Center, located at University Park, Pa. Nitrate leaching by rainfall is a principal cause of fertilizer losses. Measurements from the new technique may be used to determine whether fertilizer applications can be scheduled to minimize the loss of this important resource.

Schnabel's technique uses a cylinder filled with an ion-exchange resin (small pieces of negatively or positively charged polystyrene). The small size of the column, about 3 inches in diameter and 1 inch deep, makes the technique very versatile. The columns, which are inexpensive, can be placed in remote locations because they require no maintenance. They are positioned beneath the root zone, and then removed after the growing season for laboratory analysis.

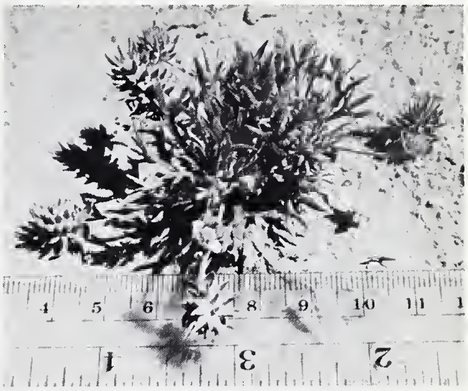
When a solution containing nitrogen flows through the resin-filled column, the nitrogen compounds accumulate in the resin. The column will accumulate nitrogen compounds over a 12-week period, which would span the growing season in the northern regions of the United States, according to Schnabel.

Soil conservationists and county extension agents should find the information gathered by this technique particularly useful, says Schnabel.

Ronald R. Schnabel is located at the Northeast Watershed Research Laboratory, 111 Research Bldg. A, University Park, Pa. 16802.—(By Ellen Mika, Beltsville, Md.) ■

Bur Buttercup Poisoning

Bur buttercup is a small weed with a soft name and a harsh surprise: long thought harmless to livestock, it is ac-



Bur buttercup *(Ceratocephalus testiculatus)* is a small range weed that is highly toxic to sheep. (PN-7037)

tually highly toxic and lethal to sheep.

"Little more than a pound of green plant can kill a 100-pound sheep," says ARS veterinarian John D. Olsen, Logan, Utah. "This lethal dose can be easily consumed in less than 5 hours when hungry sheep are put onto a range with more than 50 percent bur buttercup forage."

Treatment is generally ineffective once an animal has been poisoned, but Olsen says, "Animals on a normal grazing regimen or receiving some supplemental feed are not likely to eat enough bur buttercup to be poisoned."

Small, gray-green, and woolly, bur buttercup (*Ceratocephalus testiculatus*) is an annual, appearing between March and May, that now grows in Colorado, Idaho, Nebraska, Nevada, Oregon, Utah, and Washington, and seems to be spreading rapidly.

Mature plants are 1 to 5 inches high and feature small yellow flowers and characteristic bur-like clusters of fruit. Bur buttercup usually concentrates on foothills, sage slopes, former sheep bed-grounds, and other littered areas, but heavy stands have been reported on recently seeded crested wheat grass range. The weed is also invading grain and alfalfa fields.

The study of bur buttercup as a potentially poisonous plant was prompted in 1979 by the sudden death of 150 ewes in central Utah on a fenced, 20-acre pasture vegetated with bur buttercup (over half) and cheat-grass.

Postmortem examination by Olsen revealed "varying degrees of inflamma-

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tion and edema of the rumen; hemorrhage in the left ventricle of the heart; congestion of the lungs, liver, and kidneys; and excessive fluids in the thoracic and abdominal cavities."

Symptoms to watch for in the field, says Olsen, are "weakness, depression, diarrhea, labored breathing, poor appetite, and occasional fever."

Working with Olsen on this project are veterinary practitioner Thomas E. Anderson, Gunnison, Utah, and rancher Gary Madsen, Manti, Utah.

John D. Olsen is located at the Poisonous Plant Research Laboratory, 1150 E. 14th N., Logan, Utah 84321.—(By Lynn Yarris, Oakland, Calif.) ■

Herbicide Resistance in Sugarbeets

There appear to be genetic differences among sugarbeet varieties that give certain varieties more protection from the harmful effects of herbicides.

Garry A. Smith, ARS plant geneticist, says that if scientists were able to identify the nature of this resistance and then cross resistant varieties with commercially valuable varieties, the resulting offspring might be more herbicide resistant.

Other researchers have reported similar herbicide resistance in corn, sorghum, flax, barley, wheat, sugarcane, cabbage, soybeans, and potatoes. The potential may exist for increased herbicide resistance in these crops, too. If this is possible, more complete weed control, increased yields, reduced pesticide use, and lower consumer prices might result.

Herbicides can be very effective in controlling weeds, but they can sometimes injure the crops they were designed to protect. Frequently, the best time to apply herbicides is just when the crops themselves are most susceptible to herbicide damage. Farmers must decide if the resulting damage warrants the reduced weed population.

During his 2-year tests, Smith checked 15 sugarbeet populations; 5 inbred lines, 5 first generation hybrids, and 5 commercial varieties. Both pre- and postemergence herbicides affected the population groups, with inbreds being the most affected and commercial varieties the least.

Generally, root weight, sucrose, and purity were slightly reduced, and impurities that hinder sugar recovery were increased following herbicide applications.

Smith applied the herbicides at rates commonly used on beet fields. More striking effects would result if increased dosages had been used, he said.

Environmental conditions also affect the severity of herbicide damage. Smith found a difference in the data from the first year to the second year, although the more resistant plants in the first-year study were also the most resistant in the second.

Garry A. Smith is located at the Crops Research Laboratory, Colorado State University, Fort Collins, Colo. 80523—(By Dennis Senft, Oakland, Calif.) ■

Benefits of Permanent Wheel Tracks

If tractor operations were conducted over the same wheel tracks without tilling the compacted wheel paths over and over, energy savings could be significant, according to soil scientist Norman R. Fausey.

Working with former ARS agricultural engineer Anthony S. Dylla and the Ohio Agricultural Research and Development Center, Fausey measured corn and soybean yields from rows next to wheel tracks and from rows away from wheel tracks.

He found yields were not depressed by compacted wheel tracks along one side of the row as long as moisture and fertility were not limiting. However, when nitrogen levels were low, corn yields were 11 percent lower in rows next to wheel tracks.

Fausey suggests that wheel track depressions may facilitate surface drainage away from the row, enhancing early soil warmup and thus early growth.

"The most important aspect of the results is that neither soybeans nor well-fertilized corn suffered yield reductions due to five passes of the tractor wheel along one side of the crop row," Fausey says.

Tires were 16 inches wide and rows were 28 inches apart, leaving about 6 inches between the edge of the wheel track and the plant row. The soil was a Kokomo silty clay loam.

Norman R. Fausey is located at 2073 Neil Ave., Ohio State University, Columbus, Ohio 43210.—(By Ray Pierce, Peoria, Ill.) ■